

Beginner's Guide to ElectroDacus

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By Oberon Robinson, with awesome contributions from [Dacian Todea](#) & [FilterGuy](#)

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1 Overview

The ElectroDacus system takes care of solar charging, lithium battery monitoring, and optionally, diverting excess solar power for other uses. Its modular components can function as a BMS, a charge controller, and a thermal controller. It was designed for DIY systems, and is highly customizable — which definitely gives it a learning curve, but a very worthwhile one.

There are a number of concepts that the ElectroDacus design uniquely brings together:

- 1. Non-current-carrying.** Many battery monitoring systems (BMS) have the full current of the battery running through them, and when the battery gets to its charge limits, they switch the current off using large solid-state switches (MOSFETs). This limits the amount of current that the BMS can handle, and can also create excess heat.

ElectroDacus takes a different approach, by providing on/off signals to the battery's inputs and loads. When the battery gets full, it switches off the charging sources, and if the battery gets low, it switches off any draws. The switching function is customizable, with multiple input/output ports, and programmable set-points.

Other BMS's that have similar functionality, such as Batrium and Orion, are significantly more expensive, and lack many of the other features of ElectroDacus.

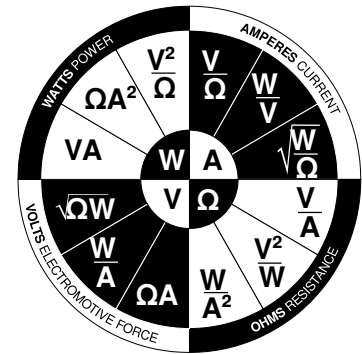
- 2. Simplified charge control.** Most charge controllers work either with maximum power point tracking (MPPT) or pulse-width modulation (PWM). The ElectroDacus approach is that neither of these technologies is necessary for lithium batteries. Instead, the solar panels are matched to the battery voltage.

This works because lithium batteries have very low internal resistance, and will draw as much current as the panels can produce. This prevents the panel output voltage from ever rising above the battery voltage – at least until the battery is full, at which point the power is switched off or diverted. So the battery inherently charges at the available power output of the panel.

In situations where it isn't practical to match the panel voltage to the battery, such as with very large solar arrays or very long cable runs, the SBMS0 can also work with a separate charge controller using remote switching.

3. **BMS in control.** In most solar systems, the solar charge controller & inverter are in control of shutting off the battery charging & discharging, based on battery voltage, and the BMS is the last line of defence. With ElectroDacus, it's the other way around. The reasoning for this is that the BMS is the only system component that can read individual cell voltages, and prevent them from going outside of safe ranges. With lithium chemistry, the battery voltage is not a good indicator of individual cell voltages.
4. **Excess power diversion.** Solar arrays are usually sized for the power output that's needed in the worst conditions. That means that at all other times, there is more solar power available than the battery's capacity. The ElectroDacus system gives you the option to divert that excess power for other purposes – such as heating, hot water, pumping, or cooling. This option can be built in to the same switch that disconnects solar charging from the battery. And for whole-home heating, there is an additional thermal controller module available for maximum heating efficiency.
5. **Continuous cell balancing while charging.** Any time there is a charge current of at least 300mA, the cells will be balanced via the same wires that are used for cell voltage sensing. ElectroDacus uses the exact same type of passive balancing as commercial EV's (Tesla, Nissan Leaf, etc).
6. **Maximizing battery cycle life.** Many inexpensive BMS's protect a battery from failure, but don't do much to extend its cycle life. ElectroDacus uses numerous methods to maximize cycle life, using safe default parameters, and all of those parameters can be customized via the built-in display.
7. **Display included.** There is a built-in colour display and controls, which allow for monitoring and adjustment, with no additional hardware. This eliminates the need for a smart shunt or external battery monitor.
8. **Data logging.** Up to a year of logs are stored internally, and can be downloaded for analysis or record-keeping. The logs include individual cell voltages, charge percentage, temperature, load current, solar charge current, and other data, each recorded at 2-minute intervals.
9. **External interface.** You can connect an external device via WiFi, USB, or UART – such as a phone, laptop, Raspberry Pi, or Arduino – for additional monitoring and control.
10. **Dual solar array.** You can set up your solar array in two parts, ideally with one part being twice as large as the other, and the best combination of parts for the current conditions will be automatically connected for optimum charging.
11. **Open source design.** The hardware and firmware are released under an open source license, so if you want to, you can build your own, and/or customize the design and coding.

This guide is intended for DIY enthusiasts who are comfortable building electrical circuits and taking multimeter readings. Knowing Ohm's law is also helpful. And you will need to source some additional components, such as shunts and resistors, which will be fully explained later in this guide.



The way the guide is structured is to first look at all the different system components, and how they interact with ElectroDacus. After that, it goes through the actual process of connecting and configuring everything together.

This is not intended to be a substitute to the [ElectroDacus manuals](#), which are written by their inventor, Dacian Todea. Reading the manuals thoroughly is essential. This is just a different way of presenting some of that information, to help make everything as clear as possible.

Where there is a cross-reference to another section in this guide, you can click on the section number and it will take you directly to that section.

2 Battery design with SBMS0

SBMS0 is short for Solar Battery Monitoring System Zero — the zero refers to the battery charging & load currents that pass directly through the unit. (They don't.) The SBMS0 is the heart of the ElectroDacus system. It will work with any lithium battery chemistry, or a supercapacitor.

Currently, the most cost-effective cell chemistry is lithium iron phosphate (LiFePO_4), so this guide will assume that's what you're using, but it's just as easy to set up other cell types if you prefer.

At the time of writing, the best values in LiFePO_4 cells on the market are EVE and Lishen cells. CALB, Fortune, and other cells are also commonly used. Just make sure to use a reputable supplier, which you can find by looking for suggestions and feedback in online solar forums.

2.1 Choosing a battery voltage

The SBMS0 can monitor 3 to 8 cells, at a total battery voltage of 8 to 32 volts. Each of the monitored cells can be made up of more than one physical cell in parallel, to create a larger effective cell and more total battery capacity.

LiFePO_4 cells have a nominal voltage of 3.2V, so in practice you will most likely use multiples of 4 cells for a 12V battery, or multiples of 8 cells for a 24V battery.

It is suggested to build a 24V battery if possible, as the currents in your system will be half what they would be with a 12V battery. This will give you multiple savings in your wire sizes and other components. Even if some parts of your system require 12V, it is likely still more cost-effective to run on 24V and add a DC-DC converter for your 12V loads.

However, if you only have space for 4 cells, or if that is enough capacity for you, then go with a 12V system.

If you want to build a 48V system, unfortunately ElectroDacus is not designed for that purpose. You could build two 24V batteries in series, controlled by two SBMS0's. But they don't have the ability to communicate with each other about their battery states, so the two batteries would gradually drift apart in charge level. And only one of the batteries would be able to get its daily state-of-charge calibration.

2.2 Battery capacity & configuration

To calculate your battery capacity, you'll need to calculate your total daily power needs, and figure out how many cells are required to handle that load. There are many other resources that cover this in detail.

Say, for example, you're using 280Ah LiFePO₄ cells, and you need a 14kWh battery, which would require 16 cells.

You could parallel your 16 cells in groups of four, then put four of those groups in series, to make a 12V battery.

Or you could parallel them in groups of two, then put eight of those groups in series, to make a 24V battery.

Both will have the same capacity of 14kWh, but the 24V battery will only need to put out half the current of the 12V battery for an equal level of power output.

The paralleled cells are functionally identical to a single larger cell of that capacity.

What is not recommended is to build 4 separate 12V batteries and connect them in parallel, or build two 24V batteries and connect those in parallel. Each of those paralleled batteries would require its own BMS, and those BMS's should be interconnected in some way. This is not a function that's built in to ElectroDacus.

If you are using many smaller cells, and you're willing to spend the time to measure their individual capacities, then a useful online resource to configure your battery pack is [rePackr](#). It was designed for 18650 lithium-ion cells, but works equally well for LiFePO₄ or other battery chemistries.

3 Solar panels

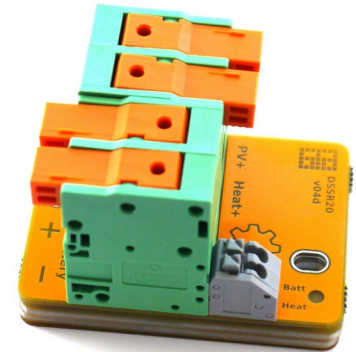
The choice of the total size of your solar array depends on many factors, including [insolation](#), available space, battery charge rate, and total daily loads. Once you know what your overall array size needs to be, you can choose the specific panels you're going to build it with.

If you're using an MPPT or PWM solar charge controller, you'll need to follow its specifications to select and wire your panels — they can usually work with a wide variety of panel sizes.

The rest of Section 3 is for information about using the ElectroDacus DSSR20 controllers, which can manage solar arrays of up to a maximum of 18kW.

DSSR20 stands for (Ideal) Diode Solid State Relay 20 — the 20 refers to the 20 amps of current that each of these units can carry & switch. They are designed to work with panels that are matched to the battery voltage...so they simply turn the charging circuit on and off.

If you choose the DSSR20 units with diversion, then when battery charging is turned off, your solar power is diverted to a different use of your choice. More on this in Section 4.



3.1 Choosing your panels

Each individual cell in a panel produces up to 0.5-0.6V, so you'll need to select a panel with the number of cells that add up to the right charging voltage for your battery. There are always some voltage losses in a system, and less-than-ideal sun conditions, so you also need some extra cells to make up for them.

Part of the ElectroDacus philosophy is that because solar panels have become so inexpensive relative to other system components, it is often more cost-effective to add more panel capacity than to design your system to be as perfectly efficient as possible.

Most panels are sold by watts, not by number of cells, so to select your panels, you may need to count the number of cells across & down, and multiply.

For a 12V system, you will generally use 32-cell solar panels – or 36-cell panels if you have longer than a ~20m (65') cable run between your panels and battery. Look for nominal 12V panels, and choose the price-per-watt that gives you the quality and warranty that you are looking for.

For a 24V system, you will generally use 60-cell solar panels – or 72-cell panels if you have longer than a ~20m (65') cable run between your panels and battery. If you get half-cut cells, they will have 120 or 144 half-cells respectively. Look for nominal 24V panels, and choose the price-per-watt that gives you the quality and warranty that you are looking for.

3.2 Arranging your panels

Each DSSR20 has a capacity of 20 amps, and up to 51 volts, of photovoltaic input. To see how many panels one of them can control in parallel, divide 20A by your panels' short-circuit current (I_{sc}).

For example, if your I_{sc} is 10A or less, you can have two of them in parallel per DSSR20. If your I_{sc} is 6.6A or less, you can parallel three of them per DSSR20 – although with more than two panels in parallel, you will need to fuse each panel.

It's also possible to use smaller panels, and for example have two parallel pairs of two panels in series, all being controlled by one DSSR20, as long as the total maximum current they produce is 20A or less.

You will need as many DSSR20's as you have sets of 20A parallel panels. For example, if you have a 10-panel array, and 2 panels paralleled per DSSR20, you'll need 5 DSSR20's.

The SBMS0 can control up to 30 DSSR20's, with a maximum array size of 18kW. For such large arrays, this may not be the most cost-effective option, so you may want to compare it with the cost of using a single large solar controller, with fewer wires to your array.

3.3 Dual arrays

If your weather and seasons give you a large variation in solar output, it can be difficult to design a solar array that always fulfills your needs. Having dual arrays can help solve that issue.

You can set up dual arrays if you have at least two DSSR20's. Ideally, one array will be half the size of the other, and the SBMS0 can charge your battery with the smaller, larger, or both arrays. This allows you to set a maximum charge rate for the health of your battery, and more panels will automatically be connected in cloudy conditions to try to maintain that charge rate.

For example, say you have 3× DSSR20's, and each of them is connected to a pair of panels that can supply 20A. So you have a maximum solar output of 60A, but say you want to keep your battery charging rate at a maximum of 20A to maximize its cycle life. You could set up two of your DSSR20's as your large array, and the other one as your small array.

That way, when there's maximum sun, just the small array will be connected, and when it's a cloudy winter day, both will be connected. The SBMS0 can automatically select charging at 1/3, 2/3, or all of your full solar power output, based on your actual charge current and your maximum charge current setting.

More details of how this is set up are explained in Section 5.5, in EXTIO Type 6.

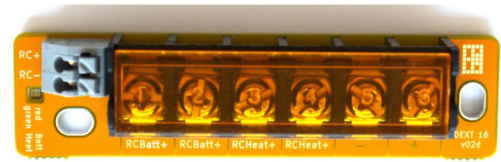
4 Diversion

So you've sized your panel array to give you enough power in the worst possible conditions. But what happens when conditions are great? Your battery will be fully charged before noon, and all the rest of your solar power is now wasted. Or is it? Not if you have a system that can automatically divert that extra power to other uses.

You could heat your house, or a hot water tank. You could power an air conditioner. Or you could run a pump to fill your pond. The possibilities are limited only by your imagination.

To enable diversion in your system, you only need to have DSSR20's with the extra diversion components installed, and one or more DEXT16 units to manage your diversion circuits.

DEXT16 stands for DSSR Extender 16, because it can connect up to 16× DSSR20's. It is an inexpensive add-on component that works with the SBMS0 to provide the necessary signals to control both solar charging and diversion.



If your diverted power needs on/off control – such as a thermostat or float switch – that can be done at low voltage, by switching the control wire to the DEXT16.

5 Controlling inputs and loads

Besides a number of other ports which are covered later, the SBMS0 has 4 external input/output ports, labelled EXTIO3 through EXTIO6. The + and – polarity on these ports doesn't actually matter, but it did on earlier versions of the SBMS0, so it is kept for backwards compatibility.

By default, EXTIO3 turns on and off the system's electrical loads, and EXTIO4 turns on and off the charging inputs — it is recommended to leave them as the default types, so that they stay the same after a system reset. However, each of the 4 EXTIO ports can be configured for any of 6 different switching modes, or turned off.

The way each of the EXTIO ports works is like an on/off switch. They do not provide any power by themselves.

The actual switching within the SBMS0 is done with a photo-relay, which has a maximum current capacity of 50mA. As the system designer, you will need to put together the trigger circuits for all of your charging inputs & loads, and make sure that the total current in each of those circuits stays below 50mA. If you aren't familiar with circuit design, this may seem intimidating, but it's really quite easy.



You will need to know the remote on/off circuit current for each device you are controlling. You may be able to find a specification for it, or simply measure it: connect the device to power, remove the jumper (if any) from the remote terminals, and connect your multimeter across them. Check the voltage, and the current. If there isn't any, it's likely that it needs an external voltage applied (see Section 5.3).

5.1 Switched trigger circuits: 50mA or below

In the simplest case, the EXTIO-switched devices will have an external trigger circuit that is closed (shorted) for on, and open for off. Most Victron products, for example, are controlled this way — although be careful, because some of them run at 5V and some (like the Orion) at 12V.

Most remote on/off circuits have a switching current that are well below 10mA. The DSSR20, and most or all Victron components, may be as low as 2mA.

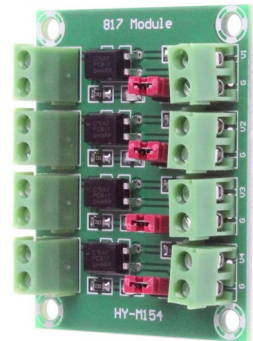
Another option for controlling Victron components is to connect their 'L' remote pin through an EXTIO to battery negative. Or, connect their 'H' remote pin through an EXTIO to battery positive — this is the correct way to wire a Battery Protect in Li-ion ('L') mode.

If you want to control multiple identical devices that have the same trigger voltage, and the total of their remote switching currents is 50mA or less, then you can connect them in parallel on one EXTIO. Just make sure that you wire all of them with the same polarity, with all positive pins on one side of the EXTIO, and all negative pins on the other side.

5.2 Switched trigger circuits: above 50mA

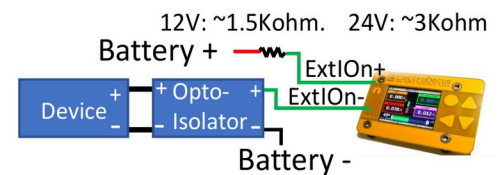
If your devices are on/off triggered, and the total switching current needed on one EXTIO port is above 50mA, then you will need a relay — ideally, an optically-isolated solid-state relay (SSR).

- The [CPC1706](#) is a good choice for many applications, and has a maximum load current of 4A. If you need to reverse the on/off signal, which is common for EXTIO Type 3, 4, & 5, you can use the [CPC1705](#).
- Some people use an 817 optocoupler board like the one shown to the right, available on Amazon. Remove the red jumpers if you use it.
- Or the [GC SSR-25DD](#) is a panel-mounted option.



In order to power the relay, you'll need to connect the EXTIO+ to your positive distribution busbar via a resistor, and the EXTIO- to the SSR input positive. Then connect the SSR input negative to your negative busbar.

Your device(s) can now be switched by the SSR load terminals.



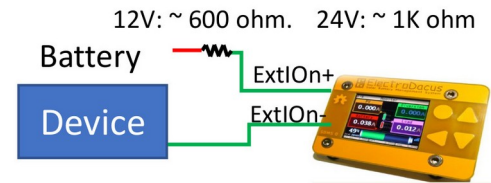
The size of the resistor depends on the minimum switching current that's required by the SSR. For example, the CPC1706 mentioned above requires 5mA to activate, so for a 24V battery, the resistor can be a maximum of $24V \div 0.005A = 4,800\Omega$. To give a safety margin, you may want to size it around 3,000 Ω . Then to check the power rating for the resistor, $V^2/R = 24^2 \div 3000 \approx 0.2W$, so with a healthy safety margin, a 0.5W resistor will be good.

See Section 9.2 for how to source your resistors.

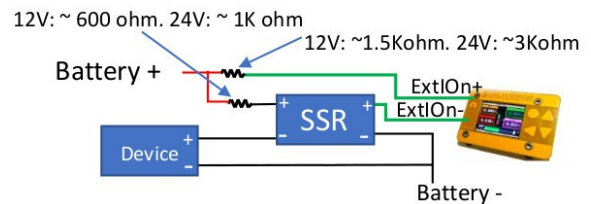
5.3 Trigger circuits that require external voltage

Some devices require an external voltage to be applied in order to turn them on and off. In this case, you'll need to dedicate one of your EXTIO ports for this purpose.

If the switching current that's required is 50mA or less, you can simply connect EXTIO+ to your positive distribution busbar via an appropriately-sized resistor, and connect EXTIO- to your load.



If the required switching current is more than 50mA, you'll need to use an SSR. In this case, to wire it in, you'll also need a resistor for both the input circuit and the load circuit.



5.4 Other control cases

- For the SBMS0 to be able to disconnect DC loads, you will need a large relay or SSR that can handle your maximum DC load current. Many people use a Victron Battery Protect for this purpose — they are relatively inexpensive, and come in multiple current ratings.

If you use one for this purpose, set it to Li-ion ('L') mode to work correctly and turn off alarms. If you use a different type of load relay or SSR, then check its drive current — if it's over 50mA, you will need an intermediate SSR or isolator as well.

- There are inverters that don't have a remote trigger circuit, but do have a physical on/off switch. In this case, you can control the switch with an EXTIO circuit, which will allow the SBMS0 to turn the inverter on and off.

This is best done with an SSR, sized for the switch voltage & current, to provide RF & voltage isolation (see Section 5.2). You may also want to remove or otherwise lock-out the original switch, because if it gets accidentally left on, the SBMS0 won't be able to turn off the inverter at low battery charge.

- Some inverters turn on and off using a momentary switch. This is more difficult to control automatically, however [Ross Freeman came up with a circuit](#) that can do it, for at least some inverters, if you're comfortable building a small circuit board.

5.5 EXTIO types

Each of the four EXTIO ports can be configured as one of six possible types, or turned off:

- Type 0: Off** — turns circuit off (open circuit) regardless of conditions. Used for testing, to disable charging or loads, or to disconnect wiring for a circuit.
- Type 1: Charge disconnect** — switches off (open circuit) when the battery reaches the 'End of Charge' upper voltage set-point. This is the default type for EXTIO4, and is used for controlling any charging source: DSSR20, MPPT charge controller, grid charger, or battery-to-battery charger. It is recommended to keep EXTIO4 as this type, so it will stay the same if your SBMS0 is ever reset.
- Type 2: Load disconnect** — switches off (open circuit) if the battery drops to the 'Low Voltage Chg' set-point. This is the default type for EXTIO3, and is used to control any loads: inverter, DC loads, etc. It is recommended to keep EXTIO3 as this type in case of a reset.
- Type 3: High charge alarm** — switches off (open-circuit) when the battery goes above its upper state of charge (SOC) set-point, OR if the Type 1 conditions are met. This can be used to set an alarm in case the charge disconnect fails for some reason and the battery gets to a higher voltage than it normally should. This type can also be used creatively, for example to turn on extra loads when the battery is getting close to full. May be tested by changing to Type 0.
- Type 4: Low charge alarm** — switches off (open-circuit) when the battery falls below its lower voltage set-point, OR if the Type 2 conditions are met. This can be used to set up an alarm, similar to Type 3. It can also be used in other ways, like connecting a backup charging source, or disconnecting an optional load. Test by changing to Type 0.
- Type 5: Fault condition** — switches off (open-circuit) if the battery reaches an outer limit of high or low voltage, which are set in the 'Voltage Lock' parameter settings. This is intended to trip a remote-triggered breaker in the unlikely event that all the other safeguards have failed.
- Type 6: Charge disconnect for dual array** — switches on or off as needed to control the charging rate from a dual solar panel array. Connect your smaller array to a Type 1 EXTIO, and your larger array to a Type 6 EXTIO, and the SBMS0 will automatically connect one or both arrays to maximize the charging rate within the set limit. Note that a PV shunt is required for this function (See 6.2). Set your max charging current as the 'Max PVOUT Current' in the DMPPT settings menu.

6 Using current shunts

The SBMS0 keeps track of your battery's state of charge (SOC) by monitoring the current flow into and out of the battery. It does this by measuring the voltage drop across a shunt at the battery positive terminal. Optionally, you can add another shunt on your solar circuit to measure your solar power generation.

A shunt is a resistor with a low but accurately-known resistance, that is able to handle high currents. Some shunts can be expensive, but have a look at Riedon or Murata for shunts that are high quality and reasonably priced. You can also order inexpensive shunts from China — they won't be very accurate, but it's possible to calibrate for the error (see Section 8.7).



Shunts are usually rated by current and voltage drop. For example, a Riedon RSB-300-50 is rated for 300A and 50mV. If you see a shunt rated by current and resistance, you can calculate its voltage drop as $V=IR$ (voltage = current \times resistance).

The current rating is the maximum current a shunt can carry. However, the maximum continuous current through your shunts should be no more than 2/3 of their rated current. If operating at elevated temperatures, your maximum current should be no more than 1/2 of the rated current.

A shunt's rated voltage drop is quoted at the rated current. The SBMS0 has a shunt voltage reading scale of 90mV — although the voltage limit on the shunt inputs is around 500mV, and above that the current shunt amplifier may be damaged.

A 75mV or 100mV shunt will give you the most accurate readings. However, if you want to reduce any heat output from your shunt, you could go with a 50mV shunt — the accuracy of the readings will still be very good. There is 16-bit resolution over $\pm 90\text{mV}$, so 32768 steps, and if you only measure a range of $\pm 50\text{mV}$ you will still have 18204 steps. For a 500A 50mV shunt, that will give you readings with a resolution of 27mA or 0.027A.

You will need to enter the resistance of your shunt(s) into the SBMS0 settings (Section 8.6). Any shunt resistance between 0.0400m Ω and 9.9999m Ω is supported. The resistance can be calculated from Voltage \div Current. For example, a 300A 75mV shunt would be:

$$75 \text{ mV} \div 300 \text{ A} = 0.25 \text{ mOhms.}$$

The SBMS0 zero-calibrates the shunts on power-up, so it's important that no current is flowing after you connect your shunts and cycle power. The automatic zero-calibration values for the shunts are shown on the Diagnostics page.

6.1 Battery current shunt

The battery current shunt is a required component, and lets the SBMS0 keep track of your battery's state of charge (SOC). It must be connected directly to the battery positive terminal — with no breaker, fuse, load, or disconnect in between.

To size your battery current shunt, calculate the maximum continuous total load current that your system may ever have. Then add 50% more – or 100% more for higher-temperature operation – and round up to the next available shunt current rating. Choose a shunt with a voltage drop of 75mV or 100mV for maximum accuracy, or 50mV for minimum heat dissipation.

6.2 PV current shunt

Installing a photovoltaic current shunt is optional but highly recommended. It measures your solar charging current, which is useful to know by itself. And it also allows the SBMS0 to calculate and log other data, such as load current, total solar energy, and total power draw — none of which can be known without it.

To size your PV current shunt, first calculate your system's maximum solar output current. If, for example, you have 3× DSSR20's, that would be $3 \times 20 = 60\text{A}$. Then add 50% more, or 100% more for higher-temperature operation, and round up to the next available shunt current rating. For the same example, $60 \times 1.5 = 90\text{A}$, so choose a 100A shunt. Then follow the same recommendations for voltage drop as above.

If you are using dual arrays (see Sections 3.3 and 5.5) then a PV current shunt is a required component.

7 Circuit protection

The main reason why it's important to have a fuse or breaker on each circuit in your system is to prevent glowing red-hot wires, smoke and fire in the event of a fault.

When you think about how much energy is stored in your battery, and then imagine all of that energy getting immediately released if one of your cables accidentally makes contact in the wrong place, it makes sense to have safety measures in place to provide an emergency disconnect.

Generally, breakers are priced significantly higher than fuses. It's up to you whether you want to invest more for breakers which can be reset, or keep spare fuses so they can be replaced. In a well-designed system, that should never be needed, but it's the real world and sometimes interesting things happen.

Fuses and breakers shouldn't be run at more than 80% of their rated value. That means that each circuit should be protected at $1.25 \times$ the maximum continuous current the circuit will see, and the fuse or breaker needs to be DC rated for at least the highest voltage across the circuit.

At the same time, the fuse or breaker should always disconnect the circuit at less than the rated ampacity of that circuit's smallest wire — including the negative. So:

Wire ampacity > Fuse rating > Maximum current in that circuit

Another factor to consider is that if your fuses or breakers will be operating at ambient temperatures above 40°C (104°F), they will need to be derated — you should be able to get temperature-dependent ratings from the manufacturer.

See Section 10.2 for more in-depth resources about DC circuit protection.

7.1 Solar panel protection

Each solar panel is rated with a short-circuit current, I_{sc} , which is the maximum current the panel produces at the standardized testing conditions. But in other conditions, the actual maximum current may be as much as 1.25 times that. And the circuit protection should be rated at 1.25 times the actual maximum current. So a fuse or breaker for a solar panel should have a rating of $1.25 \times 1.25 \times I_{sc} = 1.56 \times I_{sc}$.

Similarly, the highest rated voltage for a solar panel is the open-circuit voltage, V_{oc} . That is measured when the cell is at 25°C (77°F) — and panel voltage increases as temperature decreases. So in a cold climate, the actual maximum voltage may be up to 1.25 times the rated V_{oc} . All the over-current protection devices on your solar circuits should be voltage-rated with that in mind.

When solar panels are connected in series, their voltages add together, but the current does not. Any number of panels can be connected in series without needing extra fuses or breakers.

When panels are connected in parallel, the currents add together, but the voltage does not. Up to 2 panels can be connected in parallel without individual fuses or breakers, but 3 or more panels connected in parallel need to each have individual circuit protection, rated for a current of $1.56 \times I_{sc}$, and a voltage of up to $1.25 \times V_{oc}$ for cold climates.

If you are using the standard configuration of 2 panels per DSSR20, then you'll need one fuse or breaker for each DSSR20, rated for 32A to 40A. It should be wired in at the DSSR20 end of the cable that runs to the battery positive. You might consider Langir DC breakers for this — see Section 9.3.

7.2 Battery protection

A lithium battery can easily put out many thousands of amps in a short circuit, and a regular fuse is definitely not designed for that kind of excitement. So there should be a Class-T fuse at the battery positive, rated for at least $1.25 \times$ the maximum continuous current draw that you expect to have on your battery.

Since the SBMS0 requires the current shunt to be the first thing connected to the battery positive, your Class-T fuse should be connected immediately after that, and before the cable running to your positive distribution busbar and your loads.

7.3 Load circuit protection

For DC loads, most people add an automotive fuse block. Automotive fuses are generally rated for up to 32V DC, but they are not specifically rated for lithium batteries, so use them at your own risk. If you have both 12V and 24V loads with a DC-DC converter, you will need two fuse blocks, one for each voltage.

Your inverter will need its own DC fuse on the supply side, and an AC breaker box on its load side. The DC fuse should be sized according to your inverter's rated maximum wattage, divided by nominal battery voltage, and multiplied by 1.25. Since there can be very high current running to your inverter, you may want to consider making this a Class-T fuse as well. And always make sure that both its positive and negative wires have a larger ampacity than the fuse.

7.4 SBMS0 control-wire protection

If you are running powered control wires through your SBMS0 EXTIO ports, each of them should have a resistor at the positive busbar end of the control wire. With the resistor there, you don't need a fuse on that circuit.

If you are supplying power to the load side of any solid-state relays that are being controlled by EXTIO ports, those load circuits should also have a resistor at the positive busbar end. If there won't be a resistor in the circuit, then they should have a fuse instead.

If you are using a DEXT16, the power supply wire running to it should have a 1A fuse.

8 Connecting everything up

Finally, after all that background, we can get into connecting all of your components together.

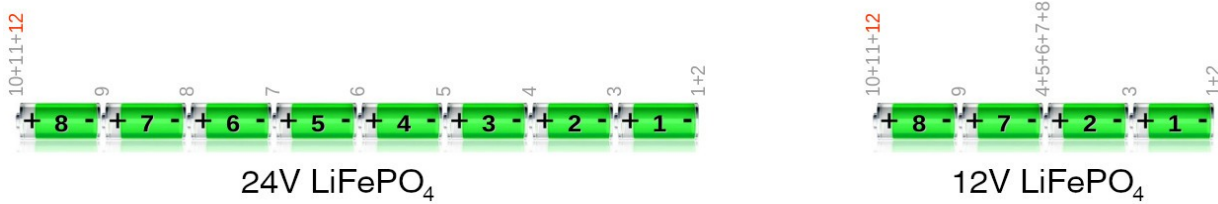
The first thing to take care of, before anything else, is to top-balance your battery cells. If you aren't familiar with this process, there is a resource linked in Section 10.2 that covers it well.

Next, follow the steps in the SBMS0 manual to connect everything together. The manual explains the process clearly, but this section gives you a summary of the important points.

8.1 Battery sense wires

Connect the ribbon cable sense wires to your battery – you might want to get some heat-shrink ring terminal connectors that fit your battery studs. 1/4" ring terminals will fit M6 studs, and 5/16" or 3/8" rings will fit M8 studs. The ribbon cable wires are 28 AWG, so you may have to double-over their stripped end to fit a 22 AWG crimp connection.

The ribbon cable can be cut shorter, but make sure to keep all of its wires the same length as each other. Leave the SBMS0 end disconnected until you are 100% sure you have the battery cell wires hooked up correctly. Start with the red wire, which is wire #12, and number them sequentially down from there.



8.2 Control wire connections

Now the control wires can be connected. These should all be in twisted pairs, which you can most easily get with a CAT5 or CAT6 Ethernet cable – solid wire is best, or you can add ferrules to stranded wire.

1. PVn & PVp — photovoltaic current shunt (see Section 6.2). PVp connects to the positive side of the shunt closest to your panels, and PVn connects to the negative side closest to your battery.
2. ADC1n & ADC1p — battery current shunt (see Section 6.1). The positive terminal is on the side of the shunt closest to your battery. The terminals are the other way around than the PV shunt terminals.
3. ADC2 & ADC3 — these are voltmeter inputs. They don't have any control function, but you can connect each of them to any wire or terminal whose voltage you would like to know, and their voltages will be logged. They have a range of 0-60V DC.
4. EXTIO3 to EXTIO6 — these are the switching control ports that are covered in Section 5. Because every system is unique, you will have to design your own control circuits, and make sure that the SBMS0 is able to turn off all of your charging sources and all of your loads.
5. XT1 — this is a battery temperature sensor circuit. It is optional but highly recommended that you connect a 10k Ω thermistor on this circuit, so the system can prevent damage to your battery if it is outside of safe operating temperatures. If your battery is in a conditioned living space or your climate never goes outside a safe range, you can leave this off. See Section 9.4 for thermistor sourcing info.

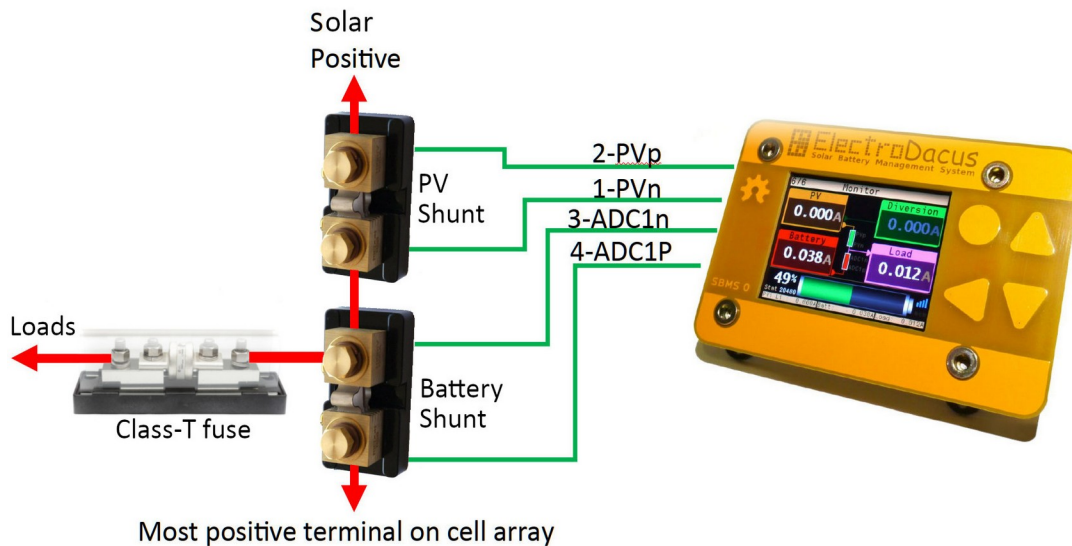


Note that the SBMS0 will disconnect both charging and discharging if it detects a battery temperature outside of the set limits. It will reconnect automatically when the temperature improves by about 3.5°C — a raw value of 100 in the ExtTemp displayed in the Diagnostic screen.

8.3 Shunt wiring

Your battery shunt must be connected directly to your positive battery terminal, with nothing else in between them. The far terminal of your battery shunt can then tee off to your solar array and your loads. The solar array branch may have a PV shunt, and the load branch should have a Class-T fuse as physically close as possible.

The voltage sense wires – ADC1n & ADC1p, and PVn & PVp – should be twisted pairs, which you can get from a CAT5 or CAT6 cable, or you can use an electric drill to twist together any other pair of wires. Pay close attention to the polarity of the wires going to the shunts — it is opposite on the battery shunt relative to the PV shunt. The ‘p’ wire goes to the more positive side, and the ‘n’ wire goes to the more negative side.



8.4 Power connections

In most cases, you will need to have positive and negative distribution busbars to be able to connect all your circuits together. These busbars should both be the same size, and rated to carry at least 25% more than your maximum total current.

Your positive battery terminal will connect to your positive distribution busbar via your battery shunt and Class-T fuse. And your negative battery terminal will connect to your negative distribution busbar. Then your loads will all connect across your positive and negative busbars, and be switched by your EXTIO control wires.

For DC loads, you will need to supply power through a power relay (see Section 5.4) to a DC fuse block. Your power relay will be switched by EXTIO3 by default.

For AC loads, you'll likely be connecting an inverter to your positive and negative distribution busbars, with a breaker or fuse (Class-T preferred) at the positive busbar. When connecting an inverter to power, it should first be connected through a pre-charge resistor for a few seconds – an incandescent light bulb works fine – to charge its capacitors. You'll also connect on/off

control wires from its remote circuit to an EXTIO port (EXTIO3 by default). If you have more than one load being controlled by one EXTIO port, see Section 5 for information on connecting them together.

Your solar panels will be connected to their DSSR20's (or other charge controller), and from there to your positive and negative distribution busbars. The control wires to turn charging on and off get connected to EXTIO4 by default.

Keep in mind that all of the current-carrying cables must be sized both by their maximum current, and the total length of the circuit, including both the positive and negative wires. For the cables carrying the largest currents, you'll want to arrange your components to give you the shortest possible cable runs.

8.5 First boot up and Parameter Settings

To power up the SBMS0, connect the 12-pin connector on the ribbon cable to the SBMS0. There should be no battery current flowing before you connect the ribbon cable.

Once it boots up, go to the 'Parameter Settings' menu, and enter your type of cell, number of cells, and battery capacity.

If you have a 10k Ω battery thermistor connected to XT1, go to 'Parameter Settings ➡ Advanced Parameters' and set your 'Min EXT Temp' and 'Max EXT Temp'. These numbers are in 12-bit binary, and some suggested numbers are given in the settings. The higher the number, the lower the temperature.

Then select 'Store Parameters' to save your data, and reboot the SBMS0 by removing the 12-pin ribbon cable connector. Wait 5 seconds, then reconnect.

8.6 Device Settings

Besides the basic parameters in Section 8.5, there are a number of other settings that you'll need to adjust to make everything work the way you want it to. Most of the default battery parameters should be left the way they are unless you really know what you're doing. Here are the basic ones that you'll need to set — and for many systems, there won't be any need to change anything else.

Each of the settings will scroll when it is selected to give you more information. See Section 11.7 for a complete listing of the menu system.

- 1) Device Settings ➡ Time & Date — these need to be set to enable data logging.
- 2) Automation ➡ EXT IOx — set the Type for each of the EXTIO ports that you have hooked up. If you're using Type 3 or 4, also set the battery state of charge (SOC) at which you want them to turn on.

- 3) Automation ➡ ADC — set your shunt resistance for your external battery shunt (see Section 6.1).

If you aren't using a PV shunt, set 'PV1 shunt On/Off' to 0. If you are using a PV shunt, set the PV1 shunt resistance (see Section 6.2).

You can also fine-tune the calibration here over time if you are finding that the currents measured by the SBMS0 are not 100% accurate compared to a good multimeter. See Section 8.7.

- 4) If using dual arrays, set 'Automation ➡ DMPPT ➡ Max PVOUT Current' to the maximum charge current that you would like the SBMS0 to try to maintain. A maximum of 0.2C to 0.3C is recommended — lower numbers give more cycle life.
- 5) Make sure you select 'Device Settings ➡ Save Device Settings' when you're finished making any changes.

Note that device settings do not require a reboot, but parameter settings do. If you reboot, you will need to reset your Time & Date settings, and the SOC will reset until the next full charge.

8.7 Shunt calibration

The SBMS0 auto-calibrates the shunts at power-up, under the assumption that there is zero current flowing into or out of the battery. In most cases, this will give you good accuracy. However, if your shunt resistances differ from their rating, your current readings will be off.

To calibrate, you will first need to have an accurately measured PV current – which you can measure with a good DC clamp meter – and zero load current. This will give equal current through the PV shunt and battery shunt, and any measurement difference between them will be calculated and shown as an incorrect load current.

The battery shunt has better zero-offset auto-calibration than the PV shunt, so first adjust the battery shunt resistance until the SBMS0 is showing the same battery current as your meter.

Then adjust the PV shunt resistance until the SMBS0 shows the same PV current as your meter, and the calculated load current is zero.

9 Sourcing circuit components

Note: this guide does not contain any affiliate links, and there is no sponsorship or affiliation with any of the products or suppliers mentioned – they are only given as examples to help you find the best options for your needs.

9.1 Shunts

See Section 6 for information on sizing your shunts. To purchase them, have a look at these sources:

- shunts.com — online retail for Riedon shunts
- [shunts on DigiKey](#) — change to your locale
- [an example of shunts from AliExpress](#) — low accuracy, no base, but cheap

9.2 Resistors

The first time you look at buying resistors, you'll notice that there are about sixteen billion variations of them. But for our purposes here, you'll only need one or two types.

See Section 5.2 for an example of calculating a resistor value for a control circuit. For this type of circuit, an axial through-hole carbon-film 1/2-watt resistor will serve most purposes:

- [individual resistor listings on DigiKey](#) — change to your locale
- [an example of a resistor kit on Amazon](#)
- [an example of a resistor kit on AliExpress](#)

Another resistor you might want to have is an inverter charging resistor. When you first connect an inverter to DC power, it will draw a huge current to fill its capacitors, which makes a big spark and can damage connectors and terminals. You can solve this problem by connecting it through a large resistor for a few seconds first. You can just use a mains-power incandescent light bulb of any size, or if you want to add a dedicated resistor to your mounting board, you can use one that's somewhere around 10Ω 25W — the actual value is not really important. Here are a couple of examples:

- [AliExpress](#)
- [DigiKey](#)

If you want to build a pre-charge resistor into an inverter disconnect, [FilterGuy came up with a nice design](#).

9.3 Fuses & breakers

As mentioned in Section 7, you can choose to use either fuses or circuit breakers to protect different parts of your system. In general, fuses are a lot more economical. But breakers also have the advantage that they can double as a disconnect.

Here are some that you might want to have a look at:

- PV breakers on [Amazon](#) and [AliExpress](#)
- [Riedon Class-T fuses](#)
- an example of a high-current inline DC fuse on [Amazon](#)
- an example of a low-current inline DC fuse on [Amazon](#)
- an example of a DC automotive fuse block on [Amazon](#)

9.4 Thermistor

Adding thermal protection to your battery is optional. But for the very low cost of a thermistor, connected to your XT1 port with a twisted pair of wires, it is cheap insurance. A 10k Ω NTC thermistor with a B25/50 of 3900 to 3950 is perfect.

- Murata thermistor on [DigiKey](#) or [Mouser](#)

9.5 Solid state relays

As covered in Section 5.2, there are various ways that you may need to use SSR's to control your system components with the SBMS0.

- The [CPC1706](#) is a good choice for many applications, and has a maximum load current of 4A. If you need to reverse the on/off signal, which is common for EXTIO Type 3, 4, & 5, you can use the [CPC1705](#).
- Some people use an [817 optocoupler board](#). Remove the red jumpers if you use it.
- The [GC SSR-25DD](#) is a panel-mounted SSR.
- To control larger DC loads, for example a DC fuse block, a [Victron Battery Protect](#) is a good option. It comes in 65A, 100A, and 220A models. No need for the 'Smart' version.

9.6 Wire

It's critical to have the right type and gauge of wire for every circuit in your system. There are plenty of charts online that will suggest a wire gauge for a given circuit length and current. Here are a few wire options that are high-quality and economical:

- [welding cable](#) for thicker gauges (check your local welding supply)
- automotive [primary wire](#) for most DC circuits
- [marine-grade cable](#) for marine or mobile systems
- [TEMCo solar cable](#)
- [solid cat5 cable](#) from Monoprice (check local hardware stores to buy by the metre, just make sure it's solid wire, not stranded)

9.7 Connectors

- standard size crimp connectors from [E-Volt](#) or [Wirefy](#) — try to find a kit that contains the connectors you need.
- [copper wire lugs kit](#)
- For the battery ribbon cable sense wires, search for Wirefy red ring terminal connectors. 1/4" ring terminals will fit M6 studs, and 5/16" or 3/8" rings will fit M8 studs. The ribbon cable wires are 28 AWG, so you may have to double-over their stripped end to fit a 22 AWG crimp connection.
- If you need ferrules to adapt a stranded wire to work in a control wire terminal, this one fits well: [DigiKey](#) or [Mouser](#)

10 Additional resources

10.1 ElectroDacus-specific info

[ElectroDacus manuals](#) — read carefully. Then read a few more times because you definitely missed something important.

[ElectroDacus Google Group](#) for online support

[ElectroDacus I/O Summary Chart](#) by FilterGuy — another very useful resource document, includes source material used in this guide. Free forum sign-up required to download.

[Momentary switch inverter control circuit](#) by Ross Freeman

[External monitoring with Raspberry Pi and Grafana](#) by David Burton

[External monitoring with MQTT and Node-RED](#) by Sherry McCampbell

[ElectroDacus software zip file](#) — open-sourced by Dacian Todea

[ElectroDacus ESP32 firmware github](#) — for the optional WiFi module, by Robert Tagscherer. Includes firmware update instructions.

10.2 General solar info

[Insolation map](#) — average solar production for locations worldwide

[Suncalc.org](#) — more solar data for locations worldwide

[rePackr](#) — combine multiple smaller capacity cells into an optimized battery

[MarineHowTo article on LiFePO₄ systems](#) — intended for marine but applicable to everyone

[Nordkyn Design series on lithium battery systems](#) — also originally for marine but has excellent in-depth information about lithium and solar

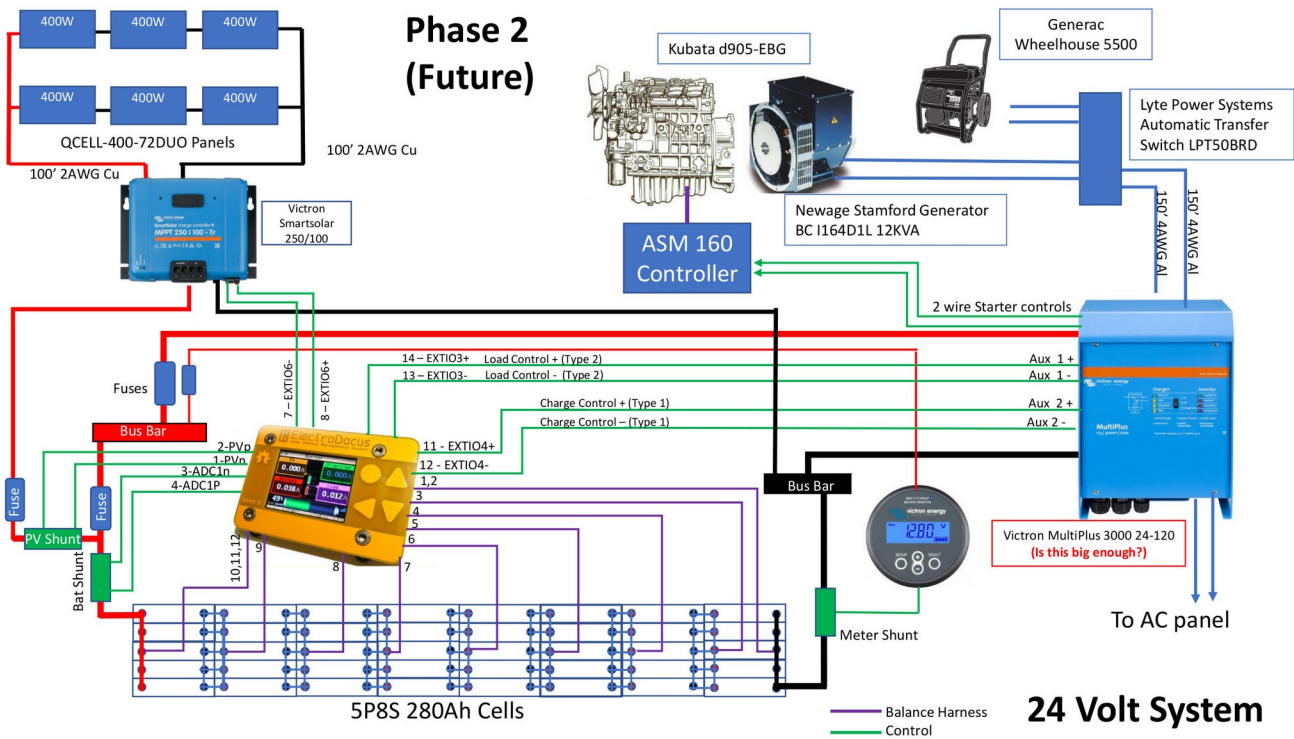
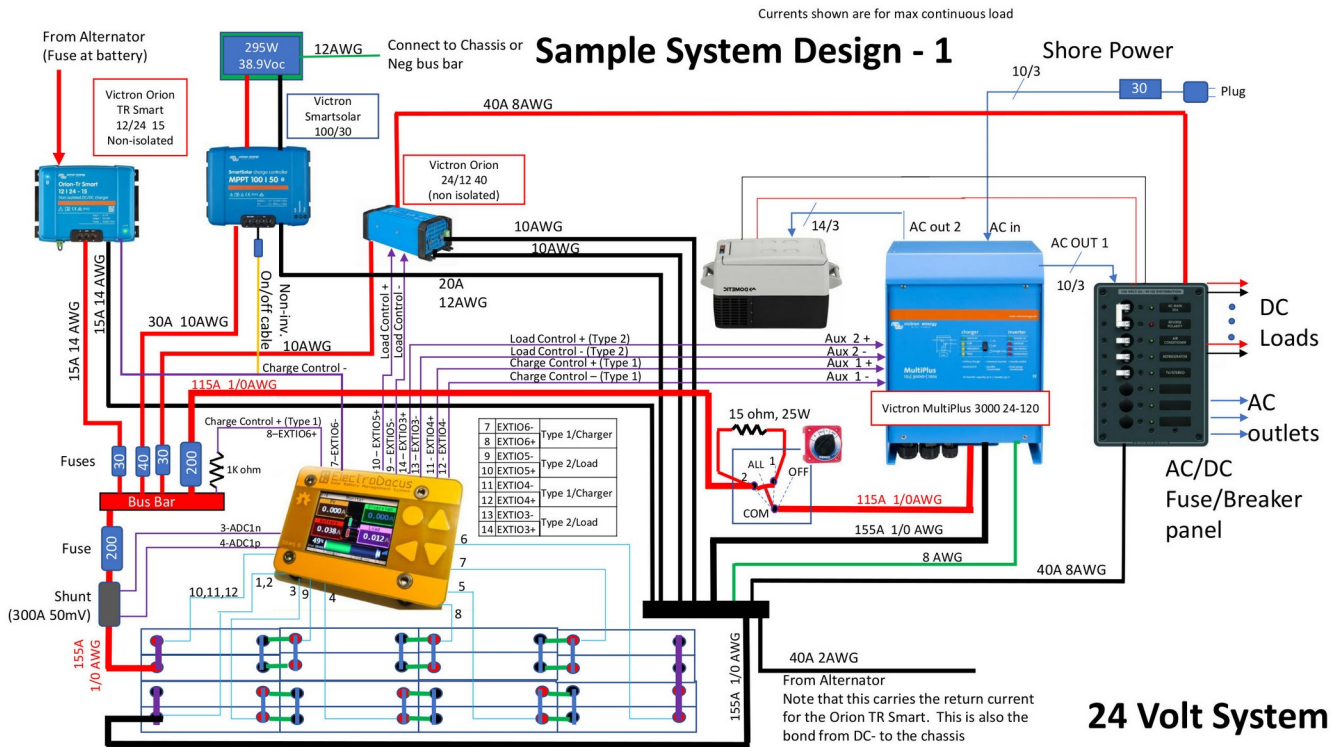
[Top-balancing lithium cells](#) by FilterGuy

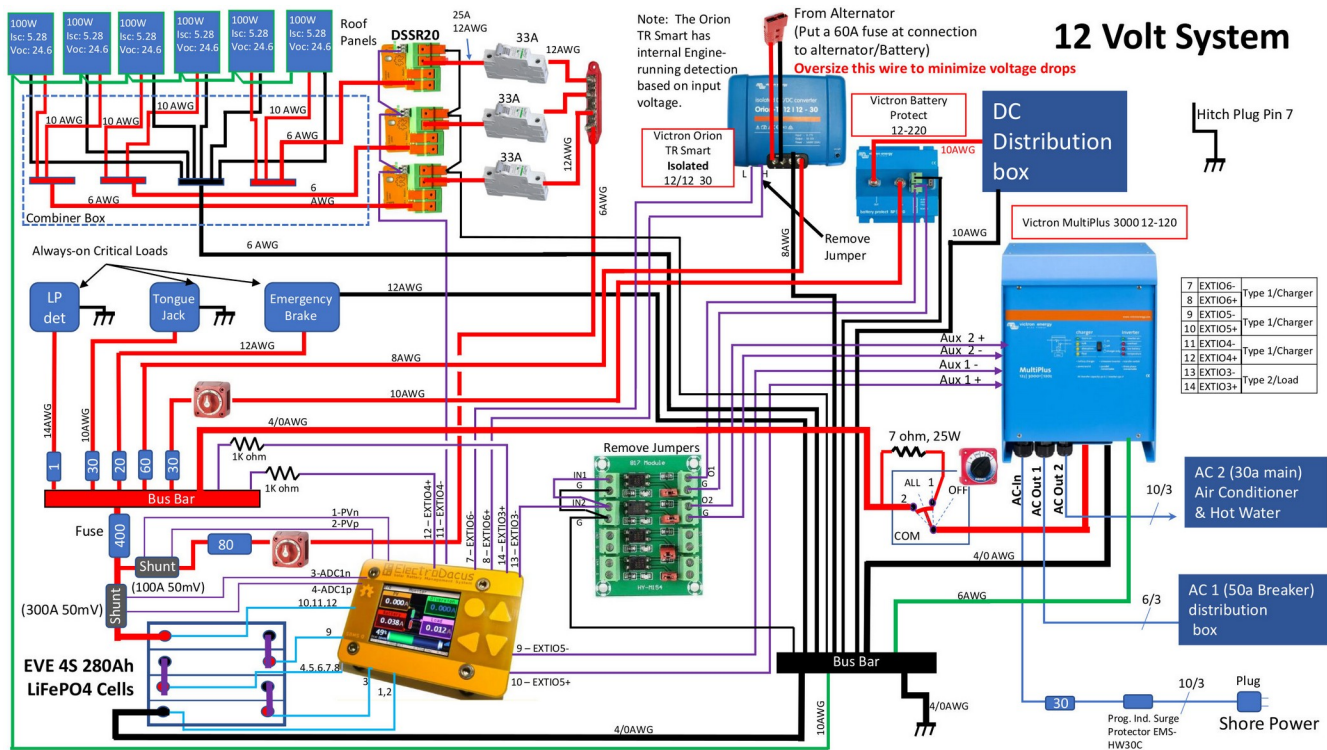
[DC circuit protection](#) by FilterGuy

[Inverter disconnect with pre-charge resistor](#) by FilterGuy

[Lots of other resources](#) for DIY solar systems

10.3 Example system circuit diagrams





11 System specs

11.1 SBMS0 16-pin green connector

#	Name	Function	Settings	Comments
1	PVn	Solar array shunt ^{1,5} (0-90mV)	PV Shunt Resistance ¹	The shunt(s) must be directly connected to the + on the battery bank. Do not put a fuse between the battery bank and the shunt(s). It can damage the SBMS voltage detectors if the fuse blows.
2	PVp			
3	ADC1n	Main Battery Shunt ^{1,4} (±90mV)	Battery Shunt Resistance ¹	
4	ADC1p			
5	ADC2	Voltage Sensor ² (0-60V)		Voltage is displayed on Screen 1 monitoring and recorded in system logs. ²
6	ADC3	Voltage Sensor ² (0-60V)		
7	EXTIO6-	Load or Charge Control ³	Type 0-6	Can be used to control additional Loads or Chargers.
8	EXTIO6+			
9	EXTIO5-	Load or Charge Control ³	Type 0-6	Can be used to control additional Loads or Chargers.
10	EXTIO5+			
11	EXTIO4-	Load or Charge Control ³	Type 0-6 (Type 1 default)	Recommended to leave as Charge Control (Type 1).
12	EXTIO4+			
13	EXTIO3-	Load or Charge Control ³	Type 0-6 (Type 2 default)	Recommended to leave as Load Control (Type 2).
14	EXTIO3+			
15	XT1-	Battery Temp Sensor	Temp Control Parameters	Only active if an external thermistor is wired in.
16	XT1+			

Note 1: The shunts should be sized at ~1.6 to 2 times the max expected continuous current. See Section 6.

Note 2: ADC2 and ADC3 have no control function. They are just voltmeters and will measure any voltage up to 60V DC. This is displayed on Monitoring Page 1, and also stored in the system logs together with other values. They are there if you want to measure and log something.

Note 3: The EXTIO's are Toshiba opto-isolators TLP172GM. Older versions of the SBMS0 used Toshiba TLP187 opto-isolators. They are capable of max 50mA.

Note 4: Pin 4 (ADC1p) is connected to the battery side of the shunt.

Note 5: Pin 2 (PVp) is connected to the side of the shunt closer to the solar panels (away from the battery).



11.2 EXTIO types

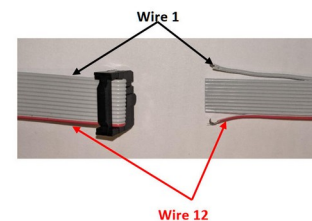
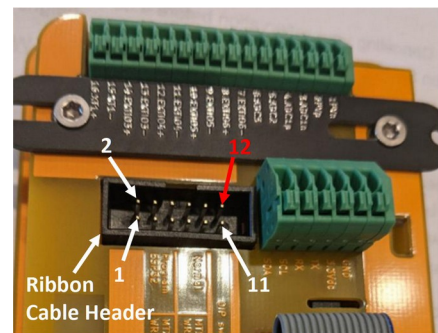
All of the EXTIO types are normally-closed. In other words, a circuit connected to them is ON while everything is within normal limits, and they turn OFF if an out-of-limits condition is met. This is a fault-safe setup, as a charger or load will not turn on if a control wire is cut.

Type	Function	State & Trigger
0	Off	Always off regardless of conditions
1	Charging disconnect	Off if battery voltage rises above 'Over Voltage' setting
2	Load disconnect	Off if battery voltage falls below 'Under Voltage' setting
3	High voltage alarm	Off if SOC rises to equal or above 'EXTIO SOC' setting
4	Low voltage alarm	Off if SOC falls to equal or below 'EXTIO SOC' setting
5	Fault condition	Off if battery voltage goes outside of 'Voltage Lock' limit settings
6	Charging disconnect for dual solar array	On or off to maintain 'Max PVOOUT Current', set in DMPPT settings. Works in conjunction with a Type 1 EXTIO to maintain optimum charging current with a dual array.

11.3 SBMS0 ribbon cable

Each wire in the ribbon cable must be run individually to the battery – do not combine wire functions together, or the cell voltage sensing will be affected.

Wire	12V Configuration	24V configuration
1	SBMS0 Power Negative ^{1,3}	SBMS0 Power Negative ^{2,3}
2	Cell 1 Negative Voltage Sense ³	Cell 1 Negative Voltage Sense ³
3	Cell 1 Positive Voltage Sense	Cell 1 Positive Voltage Sense
4	Cell 2 Positive Voltage Sense	Cell 2 Positive Voltage Sense
5	Cell 2 Positive Voltage Sense	Cell 3 Positive Voltage Sense
6	Cell 2 Positive Voltage Sense	Cell 4 Positive Voltage Sense
7	Cell 2 Positive Voltage Sense	Cell 5 Positive Voltage Sense
8	Cell 2 Positive Voltage Sense	Cell 6 Positive Voltage Sense
9	Cell 3 Positive Voltage Sense	Cell 7 Positive Voltage Sense
10	Cell 4 Positive Voltage Sense ⁴	Cell 8 Positive Voltage Sense ⁴
11	SBMS0 Power Positive ^{1,4}	SBMS0 Power Positive ^{2,4}
12	SBMS0 Power Positive ^{1,4,5}	SBMS0 Power Positive ^{2,4,5}



Note 1: With a 12V battery SBMS0 self consumption will be around 70mA.

Note 2: With a 24V battery SBMS0 self consumption will be around 35mA(?).

Note 3: Wire 1 & 2 should be on cell 1 negative terminal (most negative cell terminal).

Note 4: These leads should be on the last cell positive terminal (most positive cell terminal).

Note 5: Wire 12 is the **red wire** on the supplied ribbon cable.

11.4 SBMS0 left side connector

This connector is not available if you are using the USB/WiFi extension.

USART TX	01 02	USART RX
SDA / EXT IO1	03 04	EXT IO2 / SCL
BOOT 0	05 06	EXT IO5 / SWK
ESP RST	07 08	EXT IO6 / SWD
GND	09 10	GND
3.3V (2.7V)	11 12	3.3V (2.7V)
NC	13 14	NC
GND	15 16	GND

#	Name	Function	Comments
1	USART TX	WiFi Connector	UART TX and RX pins are used for the WiFi module so if you want to use the USART for something else then WiFi will be disabled (voltage levels 0 to 3.3V).
2	USART RX		
3	SDA / EXTIO1	I2C port	These two pins are reserved as I2C port for communicating with Digital MPPT heat controller. Firmware version 3.0g or higher has support for DMPPT450 but only for monitoring and settings with SBMS0 not charging.
4	SCL / EXTIO2		
5	Boot 0	Programming Mode Jumper	Boot 0 connected to pin 12 will put the STM32F373 microcontroller in programming mode.
6	EXTIO5 / SWK	IO5 or STM32F373. Programming SWK	This pin has dual function as programmable EXT IO5 (0 to 3.3V 20mA max) and as SWK programming interface for the STM32F373 (IO5 is the same signal as on the green connector but before the opto-isolator)
7	ESP RST	WiFi Programming Jumper	ESP Flash connected to GND will put the ESP32 WiFi module in programming mode.
8	EXTIO6 / SWD	IO6 or STM32F373. Programming SWD	This pin has dual function as programmable EXT IO6 (0 to 3.3V 20mA max) and as SWD programming interface for the STM32F373 (IO 6 is the same signal as on the green connector but before the opto Isolator)
9	GND	Ground	Same common ground plane for Pins 9,10,15,16
10	GND		
11	3.3V (2.7V)	Power	This is a 3.3V (3.15V typical) supply from the main board after going through a Schottky diode. When supplying the WiFi module it drops to around 2.7V, or if WiFi is OFF, 2.8V to supply the digital isolator.
12	3.3V (2.7V)		
13	NC	No Connection	
14	NC	No Connection	
15	GND	Ground	Same common ground plane for Pins 9,10,15,16
16	GND	Ground	

11.5 USB/WiFi green connector

These pins are isolated from the rest of the SBMS0 through a high-speed digital isolator. Remember to enable USART data logging in the 'Device Settings → USART' menu, and match the baud rate settings in the SBMS0 and your device.



#	Name	Function	Comments
1	GND	Ground	
2	3.3V DC	Power IN	If you are using USB then this side of the isolator is powered from the USB. If you want to use this with UART directly connected to Raspberry Pi or similar boards then you will need to provide 3.3V on this pin.
3	USART TX	Serial port if not using WiFi	UART TX and RX pins are used for the WiFi module. If you want to use the USART for something else, then WiFi will be disabled. Voltage 0 to 3.3V.
4	USART RX		
5	SCL/EXT IO2	Reserved for I ² C	
6	SDA/EXT IO1		

11.6 Voltage & current limits

	Max Voltage	Max Current
Battery	32V	750A
SBMS0 EXTIO ports	300V	50mA
SBMS0 ADC2 & ADC3	60V	—
DSSR20 solar in	51V open circuit	20A
DSSR20 Batt signal	30V	4mA (limited by 7k Ω internal resistor)
DSSR20 Heat signal	30V	10mA

11.7 SBMS0 menus & defaults

Note: capacitive key presses may take a few moments to register. Use the back ◀ button to go up a menu level.

Menu Item	Notes	Default
Monitoring	Choose one of 6 different monitoring screens to display	
Parameter Settings		
⇒ Cell Type	LFP, LCO, LTO, Cap	1LFP
⇒ Number of Cells	3 to 8	8
⇒ Battery Capacity	Amp-hours	200Ah
⇒ Store Parameters	Permanently store settings. Disconnect & reconnect ribbon cable to take effect. Make sure there is no battery current flowing when you reconnect the ribbon cable.	
⇒ Advanced Parameter Settings		
⇒ Cell Type	LFP, LCO, LTO, Cap	1LFP
⇒ Number of Cells	3 to 8	8
⇒ Battery Capacity	Amp-hours	200Ah
⇒ Over Voltage	If any cell voltage is above this for the delay, charging is turned off.	3.55V
⇒ Over Voltage Delay	Time required before over-voltage threshold is activated.	6s
⇒ Over Voltage Recov	If all cells fall below this voltage then charging is turned on.	3.40V
⇒ Under Voltage	If any cell voltage is below this for the delay time, loads are turned off.	2.80V
⇒ Under Voltage Delay	Time required before under-voltage threshold is activated.	3s
⇒ Under Voltage Recov	If all cells rise above this voltage then loads are turned on.	3.20V
⇒ Over Voltage Lock	If any cell above this voltage, turn charging off and Type 5 alarm on.	3.75V
⇒ Under Voltage Lock	If any cell below this voltage, turn loads off and Type 5 alarm on.	2.50V
⇒ End of Charge	If any cell exceeds this voltage, SBMS0 enters end-of-charge state.	3.53V
⇒ Low Voltage Chg	If any cell is below this voltage, charging will not be allowed.	2.30V
⇒ Over Current Charge	Not used on SBMS0.	048A
⇒ Charge Current Delay	Not used on SBMS0.	500ms
⇒ Over Current Dsg	Not used on SBMS0.	048A
⇒ Dsg Current Delay	Not used on SBMS0.	200ms
⇒ ShortCircuit	Not used on SBMS0.	192A
⇒ ShortCircuit Delay	Not used on SBMS0.	300us
⇒ Cell Balance on Dsg	Cell balancing while battery is discharging. 1=on, 0=off.	0
⇒ Cell Balance on Chg	Cell balancing while battery is charging. 1=on, 0=off.	1
⇒ Cell Balance Min	Minimum voltage for cell balancing.	3.20V
⇒ Cell Balance Max	Maximum voltage for cell balancing.	3.55V
⇒ Cell Balance Min dV	Minimum voltage difference between cells for balancing.	0011mV
⇒ Cell Balance Max dV	Maximum voltage difference between cells for balancing.	0850mV
⇒ Cell Balance ON	Balance current ON time (duty cycle).	3s
⇒ Cell Balance OFF	Balance current OFF time (needed for voltage sensing).	3s
⇒ Internal ISL	Internal over-temperature (do not change)	719mV
⇒ Min EXT Temp	Fault condition below this temp if a thermistor is connected to XT1. 12-bit binary: 0°C=3144b, +5°C=3000b (higher number=lower temp)	4096b
⇒ Max EXT Temp	Fault condition above this temp if a thermistor is connected to XT1. 12-bit binary: +50°C=1338b, +55°C=1182b, +60°C=1040b.	0000b
⇒ Sleep Voltage	ISL94203 will enter sleep mode if voltage stays below this level for the delay time.	2.30V

Menu Item	Notes	Default
→ Sleep Voltage Delay	Delay time for ISL94203 sleep voltage mode.	15s
→ Doze/Idle Delay	ISL94203 will enter Idle/Doze mode if no charge or discharge current for this time.	15m
→ Sleep Delay	After entering Idle/Doze, the ISL94203 will then enter sleep mode after this delay.	240m
→ Store Parameters	Store all parameters. Disconnect and reconnect ribbon cable to take effect. Make sure there is no battery current flowing when you reconnect the ribbon cable.	
Device Settings		
→ Time & Date		
→ Hour	24-hour clock	00h
→ Minute	0 – 60	00m
→ Day	1 – 31	01
→ Month	1 – 12	01
→ Year	2018 – 2118	2000
→ Energy Count Reset	If set to 1, reset Monitoring 2 energy counter every 24h at midnight.	0
→ LCD & TouchKey		
→ Back light level	From 1 to 32	25
→ Menu color	Choose a preset colour scheme from 0 to 9.	3
→ Back light time out	Back-light level will turn down past this delay after the last key press. 0=never.	05m
→ Key lock time out	Capacitive keys will lock out past this delay after the last key press. 0=never.	15m
→ Invert color	0 for light text on black background, 1 for dark text on white bg.	0
→ Back light sleep level	Back-light level after timeout, from 1 to 9	5
→ Invert UP/DOWN key	0 for default, 1 for inverted.	0
→ USART		
Only available with WiFi disconnected		
→ USART data logging	0=disable, 1=enable	0
→ Baud rate	USART baud rate, must be set the same on the connected device	921.6K
→ Log interval	Data logging time interval	030s
→ WiFi		
If connected		
→ On/Off	1=on, 0=off	1
→ Internal datalog		
Internal SPI Flash data log settings		
→ Month	Select the month you want to download	01
→ Start data download		
→ Save device settings	Saves all device settings plus EXTIO & ADC settings to internal non-volatile memory so after next power cycle they will be used as default.	
→ Factory reset	Will ask for confirmation	
Automation (EXT IO & ADC)		
→ EXT IOx		
See Section 5.5 for more info		
→ EXTIO3 Type	Set to 0 for off, or Type 1 – 6 for automation type.	2
→ EXTIO3 SOC	Set state-of-charge value for EXTIO3 if using Type 3 or 4.	90%
→ EXTIO4 Type	Set to 0 for off, or Type 1 – 6 for automation type.	1
→ EXTIO4 SOC	Set state-of-charge value for EXTIO4 if using Type 3 or 4.	30%
→ EXTIO5 Type	Set to 0 for off, or Type 1 – 6 for automation type.	0
→ EXTIO5 SOC	Set state-of-charge value for EXTIO5 if using Type 3 or 4.	50%
→ EXTIO6 Type	Set to 0 for off, or Type 1 – 6 for automation type.	0

Menu Item	Notes	Default
⇒ EXTIO6 SOC	Set state-of-charge value for EXTIO6 if using Type 3 or 4.	50%
⇒ ADC (ExtLoad setting)		
⇒ PV1 Shunt On/Off	1=on, 0=off. Set to 0 if not using a PV shunt.	1
⇒ ExtBattShunt value	Resistance of battery shunt in mΩ	0.1500mOhm
⇒ ExtBattShunt offset	Can be changed to calibrate load current values.	000mA
⇒ PV1 Shunt	Resistance of PV shunt in mΩ	0.7500mOhm
⇒ PV1 Offset	Can be changed to calibrate solar current values.	000mA
⇒ DMPPT & SBMS0 Settings		
⇒ Max PVOUT Current	Maximum PV charge current (limit to 0.3C)	010A
⇒ Max SOC	Used with DMPPT, maintain this SOC after full charge	99%
⇒ TLD235 1Heat 2Cool	Used with DMPPT: 0 = off, 1 = heating, 2 = cooling	1
⇒ TLD235 Temperature	Used with DMPPT: storage1 temperature limit	+60C
⇒ TLD146 1Heat 2Cool	Used with DMPPT: 0 = off, 1 = heating, 2 = cooling	1
⇒ TLD146 Temperature	Used with DMPPT: storage1 temperature limit	+60C
Diagnostic	Internal values, used for diagnostics.	
Manual & Install	Not used in SBMS0.	
About	Includes hardware & software versions, and lifetime power readings.	